

PROGRESS REPORT -- SPRAYING WITH LETHAL
OIL TO CONTROL THE MOUNTAIN PINE BEETLE
IN LODGEPOLE PINE

Introduction

A major objective of the Division of Forest Insects is the formulation of new and the improvement of existing methods of control for insects injurious to forest trees. In search of a better method of control for the western pine beetle attacking ponderosa pine, the personnel of the California station experimented with lethal oils. The method consisted of mixing or dissolving in a penetrating oil a material lethal to the insects and spraying it upon the infested tree. The oil carries the lethal material through the bark until it is in contact with the infesting brood. In spite of the thick bark on the ponderosa pine, some success was reported. It was believed even better results might be obtained with the mountain-pine-beetle-infested lodgepole pine because of its thin bark and despite its growth in a region of lower maximum temperatures, so the California station was requested to allow the more promising materials to be tested by the Coeur d'Alene station personnel. High air temperature is believed to aid materially in securing a rapid penetration through the bark and consequent effectiveness of the oils, while lower temperatures are thought to retard penetration and favor loss of both oil and lethal material through evaporation, thus decreasing its effectiveness.

Previous Tests

A preliminary test made with one oil on the Beaverhead Forest in 1934 was attended with sufficient success to justify continuation of the experiment. Early in the summer of 1935 the experiments were continued in an area near Antelope Flat on the Targhee Forest which was being devastated by a mountain pine beetle infestation in lodgepole pine. Thirty-three trees treated with three different oils gave fairly good control and a basis for comparing the effectiveness of the oils.

The possibilities of fall control were tested by spraying a few trees in October of 1935, and examining them the following spring. The control obtained was quite encouraging, sufficiently so to indicate that fall control may be feasible.

From the results obtained in 1935 and 1936 the oils which contained orthene, or a combination of orthene and naphthalene, gave the best results, but the hoped-for 100 percent control was not obtained. Survival was chiefly at the base where the bark was thick or green, but occasional brood was also present in the sprayed portion above that height. Above the base of the tree the reasons for survival are not clear, but where thick bark does not protect the insects, insufficient spraying is believed to be the cause.

Experiments Conducted in 1937

In 1937 experiments with the oils that had given the best results

in 1935 and 1936 were continued as well as with other materials offering promise of giving good control.

Trees selected for the experiments covered as representative a set of conditions as possible for the locality. Another requirement of the trees selected was ample brood to at least 6 feet, as indicated from examination under small areas of bark on portions of the trees that were not to be treated. Owing to the variability in brood conditions which have been observed in different groups of trees attacked by the mountain pine beetle, a proportionate number of trees were treated with each material in each group. This arrangement, together with the light infestation, resulted in the scattering of trees for each treatment over considerable area. Sufficient trees were also left untreated in each group to serve as checks or controls for the treated trees.

Treating the Trees

For the purpose of the experiment, the treating of one-half of the bark surface of a tree to a height of four feet was considered sufficient. The north half of the tree was the part selected, as the small amount of sunlight received by that portion was believed to represent the most difficult test of the treatment. As has been previously mentioned, sunlight is thought to materially increase the effectiveness of lethal oils. Only a sufficient number were sprayed on the south side to observe any unforeseen effects that spraying on that side might show.

Examination of the Trees

In examining the treated trees one or more $1\frac{1}{4}$ square foot samples of both the treated and untreated sides, supplemented by extensive examinations, were made in order to be more certain of the effectiveness of the treatments. Examination of so much surface was necessary because of the comparatively light brood present in the trees this season.

Check trees were given two examinations--the first on June 15 during the period when most of the spraying was being conducted, and again in July when the treated trees were examined. The two examinations were made not only to give an indication of brood status at the time of spraying and of examining the treated trees, but to furnish data on normal brood mortality during the interval between these two periods.

TREATMENTS IN 1937

Formula A

This formula consisted of the following materials:

Light stove oil	---	3 parts
Heavy stove oil	---	1 part
Orthene	---	1 part
Naphthalene	---	$3\frac{1}{4}$ lb. per gallon of oil

The preceding formula was given the most exhaustive test because of the promising results during previous years. Fifteen trees were treated on June 10; 15 more on June 16; 18 on the 23rd; and 10 on July 8, the successive treatments having for their objective the determining of the period during which effective control can be secured. The data from the intensive and extensive examinations are given in table I under subheadings for the date sprayed.

Table I

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
JUNE 10, 1937 -- FORMULA A

Data from Intensive Examination of Base of Treated and Untreated Sides										
Number of trees sprayed	Brood on treated side					Brood on untreated side				
	Dead	Per sq. ft.	Percent of total on side	Living	Per sq. ft.	Percent of total on side	Dead	Per sq. ft.	Percent of total on side	Living
	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :
15	: 36.2	: 100	: -	: -	: 1.2	: 10.9	: 9.8	: 89.1		

Notes from Extensive Examination

Tree: Amount of brood				Notes			
No.	Treated	Untreated		Treated side	Untreated side		
163	Med.	Med.		: 3 living larvae under green patch -- 100% mortality elsewhere	: Only normal mortality		
164	Heavy	Med.		: 1 living larva -- no apparent reason for its survival	: Only normal mortality to medium living brood of larvae, pupae, and new adults		
165	Med.	Light		: Large number of dead brood in intensive sample due to sample variation -- 100% control	: Only normal mortality to light brood of pupae and new adults. Large number of dead brood again due to sample variation.		
166	Light	Med.		: All brood killed under 8 sq.ft. of bark except 2 pupae from under a thick patch	: Brood of pupae and new adults showed only normal mortality		
167	Med.	Heavy		: Medium brood of larvae all killed	: Heavy brood of living new adults		
168	Med.	Med.		: Thick bark probable reason for survival of few larvae and 1 pupa in 8 sq. ft. of bark	: Medium number living pupae and new adults		
169	Med.	Heavy		: Few living larvae and pupae in green patch at base and 1 larvae in crevice under thick bark at 4 ft.	: Heavy brood of living pupae and new adults		
170	Light	Light		: Tree contained only light brood of which all were killed on the treated side	: Living brood of pupae showed only normal mortality		

Table I (Continued)

Notes from Extensive Examination

Tree:	Amount of brood :			
no.	Treated:	Untreated:		
	: side	: side	Treated side	: Untreated side
171	: Med.	: Light	: Presence of only dead brood indicates 100% control	: Light brood living pupae and new adults
	:	:		:
172	: Light	: Light	: Light brood at time of spraying all killed by treatment	: Few living larvae and new adults at base of tree indicate poor brood tree
	:	:		
173	: Med.	: Light	: Medium brood of mature larvae entirely controlled by treatment	: Light living brood of pupae and new adults showed only normal mortality
	:	:		
174	: Med.	: Light	: All brood dead indicates treatment 100% effective	: Only normal mortality noted in brood on untreated side
	:	:		
175	: Med.	: Heavy	: Only 2 larvae and 1 pupae under thick bark survived of moderately abundant brood	: Abundant living brood
	:	:		
176	: Light	: Med.	: Light brood all dead indicates 100% control Woodpecker work may have increased effectiveness	: Numerous living larvae, pupae, and new adults under 2 sq. ft. of bark
	:	:		
177	: Light	: Light	: All of light brood apparently killed by control measures	: Only light brood remaining -- most of it parasitized by Coeloides

Table I (Cont.)

SPRAYED JUNE 16, 1937 WITH FORMULA A

Data from Intensive Examination of Base of Treated and Untreated Sides												
Number of of trees sprayed	Brood on treated side						Brood on untreated side					
	Dead	Percent of sq. ft.	Per total on side	Living	Percent of sq. ft.	Per total on side	Dead	Percent of sq. ft.	Per total on side	Living	Percent of sq. ft.	Per total on side
	15	27.7	98.7	4	1.3	4.0	11.0	32.5	89.0			

Notes from Extensive Examination

Tree:	Amount of brood :	Notes from Extensive Examination											
no.	Treated:Untreated:	Treated side						Untreated side					
	:side :side												
82	Light : Light			No notes					No notes				
85	Light : Heavy			:5 sq. ft. revealed 2 surviving larvae in green section of bark. Light brood on this side					Fairly heavy brood of larvae, pupae, and new adults under 3 sq. ft. of bark, all alive				
92	Med. : Med.			:2 sq. ft. revealed medium brood of nearly mature larvae controlled - 4 living larvae under thick, green bark					:2 sq. ft. showed medium brood living larvae, pupae, and new adults				
97	Heavy : Heavy			:4 sq. ft. revealed only 2 living larvae of heavy brood. Survival possibly result of insufficient treatment					:2 sq. ft. showed heavy brood all stages living				
110	Light : Light			Numerous deep grooves protected by thick bark probable cause of only 75% kill of brood: Light basal brood of all stages surviving									
118	Light : Light			:2 sq. ft. showed complete control of nearly mature larvae killed by treatment - thin bark likely aided control					:2 sq. ft. revealed light brood of living new adults. Thin bark, woodpecker work, and ex- cessive drying resulted in small brood				
121	Light : Heavy			:1½ sq. ft. revealed complete control of light brood. Ips sp. attacked subsequent to spraying					:1 sq. ft. revealed 1 pupae and 24 new adults on one sq. ft. of bark. Little recent mortality				
123	Heavy : Med.			:1½ sq. ft. failed to show any living brood in spite of deep creases, thick bark, and very moist condition					:1 sq. ft. revealed 1 pupae, 15 new adults, and no recent mortality				

Table I (Cont.)

Notes from Extensive Examination					
Tree:	Amount of brood :				
no.	Treated	Untreated			
: side	: side		Treated side	:	Untreated side
130 : Light	: Heavy		: 2 sq. ft. revealed none of light brood living	: 1.5 sq. ft. revealed heavy living brood in base	
131 : Med.	: Heavy		: 1 sq. ft. showed 2 living larvae under wet bark over $\frac{1}{2}$ " thick at base	: $\frac{1}{2}$ sq. ft. bark at base revealed 12 living new adults	
137 : Light	: Med.		: 1.5 sq. ft. revealed light larval and pupal brood dead on treated side	: 1 sq. ft. bark revealed 15 living new adults and 3 pupae. Secondaries very abundant	
145 : Heavy	: Heavy		: 1.5 sq. ft. showed only 1 larva and 3 pupae under spot of very thick bark. Rest of treated area showed excellent control	: 2 sq. ft. revealed only a few living pupae and new adults due to woodpeckers and Coeloides	
146 : Light	: Heavy		: 3 sq. ft. revealed no living insects, only light dead larval brood. Ips sp. attack after treating	: 2.5 sq. ft. showed heavy living brood in all stages of development	
159 : Heavy	: Heavy		: 3 sq. ft. showed only 4 living larvae under thick bark at the base--heavy brood killed	: Abundant brood in all stages of development over entire untreated half of tree to 4.5 feet living	
160 : Light	: Heavy		: 2.5 sq. ft. revealed 3 living larvae in base of tree under moist bark--remaining light brood controlled	: 3 sq. ft. revealed abundant living brood in all stages at base, to sparse, highly parasitized brood above	
			: Survival on treated side almost entirely confined to thick bark, wet sections, or green areas, usually at base of tree. Living brood largely confined to base of tree, only about 30% of observed brood being alive at 6 feet. Winter kill or other factor apparently responsible for high mortality.		

Table I (Cont.)

SPRAYED JUNE 23, 1937 WITH FORMULA A

Data from Infensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side				Brood on untreated side			
	Dead		Living		Dead		Living	
	Per sq. ft.	Percent of total on side	Per sq. ft.	Percent of total on side	Per sq. ft.	Percent of total on side	Per sq. ft.	Percent of total on side
18	19.1	93.8	1.3	6.2	1.7	11.3	13.2	88.7

Notes from Extensive Examination

Tree:	Amount of brood :		Treated side		Untreated side
no. : Treated: Untreated:	: side : side :				
76 : Heavy : Heavy	: 1 sq. ft. showed 25 dead larvae and pupae, 2 pupae and 2 new adults living--the living insects under thick bark		: 1 sq. ft. revealed 1 larva, 4 pupae, and 16 new adults living and no recent mortality		
80 : Heavy : Heavy	: 2 sq. ft. revealed 14 dead larvae and 2 living pupae--the latter under very thick bark over crease in bark		: 1/2 sq. ft. yielded 14 new adults under very tight, dry bark		
91 : Light : Light	: 1 sq. ft. showed 6 dead larvae and 2 dead new adults. Poor brood tree		: 1 sq. ft. revealed very light brood of only 2 new adults--no recent mortality		
94 : Light : Med.	: 2 sq. ft. revealed only 4 larvae, all dead		: 1/2 sq. ft. showed only medium brood and no recent mortality		
100 : Med. : Light	: 3 sq. ft. showed complete control of medium larval and pupal brood		: 1 sq. ft. yielded only 3 living new adults--light brood had been controlled by parasites, predators, and dryness		
111 : Heavy : Heavy	: 1 sq. ft. showed 15 larvae and 2 pupae, all dead		: 1/2 sq. ft. showed heavy living brood--35 new adults and 6 pupae. No recent mortality		
126 : Light : Light	: 1 sq. ft. revealed only 3 living new adults under thick bark. Survival possibly due to insufficient oil		: 3/4 sq. ft. gave light living brood of new adults		

Table I (Cont.)

Notes from Extensive Examination			
Tree:	Amount of brood :		
no.	Treated	Untreated	
: side	: side	: Treated side	: Untreated side
138	: Light	: Light	: 1.2 sq. ft. showed only 1 pupae living of : light brood
149	: Light	: Med.	: 2 sq. ft. at base failed to show any survivors under thin bark
153	: Med.	: Med.	: 2 sq. ft. showed dead brood even at base and in deep crevices
161	: Light	: Light	: 4 sq. ft. revealed all brood dead but 1 larvae--no explanation for that except poor treatment
186	: Light	: Light	: 1.5 sq. ft. revealed very light brood of dead larvae, chiefly at extreme base
192	: Light	: Heavy	: 3.5 sq. ft. revealed 100% control of light brood
202	: Light	: Light	: 1 sq. ft. showed light brood all killed
206	: Heavy	: Heavy	: .5 sq. ft. showed heavy brood of 29 larvae all dead
152	: Med.	: Heavy	: 1.5 sq. ft. showed all brood dead, 25% killed by Coeloides, rest by treatment
198	: Light	: Light	: 1.5 sq. ft. revealed 100% control
205	: Med.	: Light	: .75 sq. ft. revealed 25 dead larvae--100% control

Table I (Cont.)

SPRAYED JULY 8, 1937 WITH FORMULA A

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side			Brood on untreated side		
	Dead : Per sq. ft.	: Percent of total on side:	Living : Fer sq. ft.	Dead : Per sq. ft.	: Percent of total on side:	Living : Fer sq. ft.
10	10	100	-	1.2	14.3	7.2 : 85.7

Notes from Extensive Examination

Tree: no.	Amount of brood: Treated:Untreated: side : side	Treated side (1)	Untreated side
233	Med. : Heavy	: 3/4 sq. ft. showed 7 larvae, 5 pupae, and 3 new adults, all dead--brood medium	: 3/4 sq. ft. showed 2 larvae, 15, new adults, 2 pupae. Heavy woodpecker work
234	Light : Light	: 1 sq. ft. revealed 1 new adult	: 3/4 sq. ft. revealed 1 pupae, 3 new adults living and 3 dead larvae--no apparent reason for recent death of larvae
235	Heavy : Heavy	: 3/4 sq. ft. showed 8 larvae and 12 dead Coeloides sp.	: 1 sq. ft. revealed 1 pupae and 15 new adults
236	Heavy : Med.	: 2 sq. ft. revealed 11 larvae, 5 pupae, and 4 new adults all dead	: 1 sq. ft. revealed 7 living new adults-- no recent mortality
237	Heavy : Heavy	: 2 sq. ft. revealed 21 pupae, 12 new adults all dead--brood dead even under 3/8 inch bark	: 2 sq. ft. showed 2 pupae, 35 new adults, all living--no recent mortality
238	Light : Light	: 1/8 sq. ft. revealed no living brood--control	: 1 sq. ft. revealed no living brood--no recent mortality
239	Med. : Heavy	: occurred in pupal and new adult stages	: Dead brood numbered 2 larvae and 3 new adults: 1 sq. ft. revealed 28 larvae and 12 pupae
		: living brood of 4 pupae and 1 larva, found control only partial due to thick bark	: living--12 of the larvae from overwintering parent adults.
240	Light : Med.	: 1 sq. ft. revealed complete control of light: 1 sq. ft. uncovered 10 living new adults--new adult brood	: no recent mortality

Table I (Cont.)

Notes from Extensive Examination

Tree:	Amount of brood :		
no.	Treated:	Untreated:	
:	:side	:side	
		Treated side (1)	Untreated side
241	: Light	: Light	: 1 sq. ft. examined--no survivors
	:	:	: 1 sq. ft. examined--no living brood
			: 2.5 sq. ft. revealed 3 larvae and 3 new
242	: Light	: Light	: adults dead--treatment successful even
	:	:	: under 3/8" bark

(1) Trees 233-237 were treated on the north side, 238-242 on the south side.

Inspection of the tables shows little difference in the effect of treating at four different times. Apparently there are times during the year when the lethal oil acts quite rapidly, as only 12 and 13 days elapsed between treatment and examination of the last trees to be treated with this formula. The average degree of control was nearly 100 percent, with only an occasional unaccountably surviving insect. In general the survivors were present only under what is considered very thick lodgepole pine bark or under wet or green areas. As the oil gives very uncertain results where bark is more than one-half inch thick, it is very fortunate that such bark is found on only a few very large trees. The occasional insects for whose survival no reason is apparent were probably under an area of bark too lightly sprayed, or else were highly resistant to poisoning.

The insects surviving under lightly sprayed areas of bark indicate the necessity for thorough spraying, especially those trees with part or all of the bole covered with thick bark.

With the 1937 treatments confined to the base of the tree, where resistance to control by lethal oils is probably the greatest of any area on the tree, it may be reasonably expected that the data given in all tables will give a conservative index of the effectiveness of the treatment.

To secure an indication of the brood present in the treated trees at the time of treatment and in untreated trees at the time they were examined, 15 check trees were examined near the base on the north and south sides. Brood development data at the time of treating

are shown in table II under date of June 18, 1937. No extensive examination was made at that time, as it would have made a second examination of approximately the same area in these trees impossible. The second examination, which was both intensive and extensive, was made between July 12 and 21, 1937. The data for that period are also shown in table II under the period heading.

Table II

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE
CHECK TREES EXAMINED JUNE 18, 1937

Data from Intensive Examination of Base of Check Trees										
Number of trees examined	Brood on north side					Brood on south side				
	Dead	Percent of total on side	Per sq. ft.	Living	Percent of total on side	Per sq. ft.	Dead	Percent of total on side	Per sq. ft.	Living
	: Per sq. ft.	: Percent of total on side	: Per sq. ft.	: Living	: Percent of total on side	: Per sq. ft.	: Dead	: Percent of total on side	: Per sq. ft.	: Percent of total on side
15	: 6.2	: 23	: 20.7	: 77	: 10.3	: 19.5	: 42.5	: 80.5		

EXAMINED JULY 12-31, 1937

14	:	.7	:	6.3	:	10.6	:	93.7	:	.7

Notes from Extensive Examination

Tree:	Amount of brood:	:
no. :	North : South:	:
: side	: side	: North side
: :	: :	: :
1 : Light	: Light	: $\frac{1}{2}$ sq. ft. showed a few larvae from 1937-laid: $\frac{1}{2}$ sq. ft. showed light brood of new adults
: :	: eggs	: :
2 : Med.	: Heavy	: No data
: :	: 2 sq. ft. showed no living brood, all having: $\frac{3}{4}$ sq. ft. showed 2 larvae, 1 pupa, and 1	: Larvae probably from eggs laid in 1937
3 : Light	: Light	: been killed by Coeloides sp.
: :	: Light surviving brood in all stages of de-	: new adult
4 : Light	: Med.	: velopment
: :	: $\frac{1}{2}$ sq. ft. showed light living brood of	: $\frac{3}{4}$ sq. ft. showed 2 larvae and 5 new adults,
5 : Light	: Light	: pupae and new adults mainly in basal foot
: :	: :	: with some recent mortality in mature larval
6 : Light	: Light	: Chiefly only secondaries present
7 : Light	: Light	: No notes
: :	: 1 sq. ft. showed very light brood of pupae	: Light brood living
9 : Light	: Light	: and new adults
		: No notes
		: 1 sq. ft. showed very light brood of pupae
		: and new adults

Table II (Cont.)

Notes from Extensive Examination

Tree:Amount of brood :				Notes
no.	: North	: South:	: side	: side :
				North side
10	: Light	: Light	: base	: Light brood surviving, chiefly new adults in base
				: Light brood surviving, chiefly new adults in base
11	: Light	: Light	: moist bark--side over ½ green	: ½ sq. ft. showed 5 young larvae under very moist bark--side over ½ green
				: 1 sq. ft. showed 4 young larvae--few egg galleries
12	: Heavy	: Heavy	: wintering parent adults	: 1 ½ sq. ft. showed 22 larvae, 3 pupae, and 13 new adults--larvae chiefly from overwintering parent adults
				: ½ sq. ft. showed 1 larva, 1 pupa, and 18 new adults--a heavy brood--little mortality of recent origin on either side at base
13	: Med.	: Light	: yond egg stage	: ½ sq. ft. showed 2 larvae, 3 pupae, and 8 new adults. Most brood hadn't advanced beyond egg stage
				: 1 sq. ft. yielded 2 new adults
14	: Med.	: Light	: tree base. No recent mortality	: 1 sq. ft. yielded 1 pupa, 6 new adults near tree base. No recent mortality
				: 1 sq. ft. yielded 1 pupa, 6 new adults. No recent mortality
15	: Med.	: Med.	: stages of development	: ¾ sq. ft. yielded medium brood in all stages of development
				: ½ sq. ft. yielded medium brood in all stages of development

A study of the survival on the treated sides compared with the same untreated side of the check trees clearly indicates the effectiveness of spraying with Formula A. However, for a more condensed comparison of the results obtained, table III has been prepared. The decided contrast in survival for the same side on treated and untreated areas are clearly seen in the data presented. For the first three sprayings only about 1.8 percent of the brood present at the time of treating survived and probably emerged from the treated areas. In contrast, 77 percent of the brood was alive on similar areas on the untreated trees. For the late treatment the intensive examination revealed no survival, and the extensive examination showed only five living insects over a large area examined. In contrast, nearly 94 percent of the brood was found alive on the same side in the untreated trees.

From the survival observed under very thick, wet, or green bark it seems unlikely that complete control can be expected with this formula, but control is so near complete as to make its use feasible as a control measure.

Table III

SUMMARY OF BROOD MORTALITY IN TREES TREATED
WITH FORMULA A AND IN CHECK TREES
TARCHUS FOREST - 1937

Treated Side of Sprayed Trees and North Side of Check Trees					
:	:	:	:Average of :		
:	:	:	:previous tree:		
Date treated	: June 10	: June 16	: June 23	: treatments	: July 8
Total brood per					
square foot	36.2	28.7	20.4	28.4	10
Percent of					
total brood					
Dead	100	98.7	93.8	98.2	100
Living	-	1.3	6.2	1.8	-
Check Trees					
Date examined				: June 18	: July 12-21
Total brood per					
square foot				26.9	11.3
Percent of					
total brood					
Dead				23	6.3
Living				77	93.7

Formula B

This formula consisted of the following materials:

Light stove oil	---	3 parts
Heavy stove oil	---	1 part
Naphthalene	---	1 lb. per gallon of oil

Two tests were made of this formula, one on June 24, 1937 and the second on July 9, 1937. Good control was secured in both cases, with the data from the June 24 treatment showing the better results. However, the combined data from both intensive and extensive examinations for both times of treating indicate less than two percent survival. On that basis there is little to choose between the effectiveness of Formulas A and B.

The data for both intensive and extensive examinations are shown in the two parts of table IV.

Table IV

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED
WITH LETHAL OIL---SPRAYED JUNE 24, 1937 WITH FORMULA B

Data from Intensive Examination of Base of Treated and Untreated Sides										
Number of trees sprayed	Brood on treated side					Brood on untreated side				
	Dead	Per	Percent of total on side	Living	Per	Dead	Per	Percent of total on side	Living	Per
	sq. ft.	total on side	sq. ft.	total on side	sq. ft.	total on side	sq. ft.	total on side	sq. ft.	total on side
18	26.2	98.3	.4	1.7	2.5	14.3	15.2	85.7		

Notes from Extensive Examination

Tree:	Amount of brood :	Treated side	Untreated side
no. :Treated:Untreated:			
:side :side :			
77 : Med. : Heavy	:1.5 sq. ft. uncovered fairly heavy brood in :larval stage, all dead	:1.5 sq. ft. showed heavy brood in all stages of development	
84 : Med. : Light	:2 sq. ft. revealed fairly heavy brood in :larval stage, all dead	:1.5 sq. ft. revealed very light brood in all stages of development	
89 : Med. : Med.	:2.5 sq. ft. showed fairly heavy brood, :mature larvae, all dead	:1.5 sq. ft. uncovered 2 larvae, 2 pupae, and :8 new adults below 2 ft. in wet bark. Heavy :parasitism by Coccophagus	
93 : Light : Light	:1 sq. ft. revealed light brood, all killed :except 1 larva apparently under lightly :sprayed spot	:1 sq. ft. revealed light living brood	
95 : Med. : Light	:2.5 sq. ft. uncovered medium brood either :killed by treatment or parasitized	:2 sq. ft. showed only light brood had been :present--all died as small larvae or were :parasitized.	
101 : Med. : Light	:1 sq. ft. showed complete control of larvae :and pupae	:1 sq. ft. showed very light brood new adults :and pupae	
107 : Heavy : Heavy	:5 sq. ft. uncovered 3 living new adults :and much dead brood--no apparent reason :for survival	:All brood dead on untreated 3 sides	

Table IV (Cont.)

Notes from Extensive Examination					
Tree:	Amount of brood :		Treated side	:	Untreated side
No.	Treated:	Untreated:			
:side	:side	:			
114	Light	Med.	:1.5 sq. ft. revealed light brood of dead larvae, except for 1 larvae under area :probably too lightly sprayed	:	:1 sq. ft. showed medium brood in pupal and new adult stages
124	Light	Light	:1.5 sq. ft. revealed light brood all dead	:	:1 sq. ft. revealed very light brood of living larvae, pupae, and new adults
133	Med.	Med.	:1 sq. ft. revealed 1 living larva under upper end of green strip of thick bark	:	:1 sq. ft. uncovered 1 larva and 7 new adults living
134	Light	Med.	:1.5 sq. ft. showed light, dead larval brood	:	:1 sq. ft. showed medium living brood in all stages
143	Light	Med.	:1 sq. ft. uncovered light, dead brood of larvae	:	:1 sq. ft. revealed medium brood living new adults and pupae
151	Heavy	Heavy	:2.5 sq. ft. showed 2 larvae and 1 pupa liv- ing of heavy brood. Survival under .3-inch bark adjoining green strip	:	:1.5 sq. ft. uncovered 17 new adults, dead
179	Light	Light	:1.5 sq. ft. revealed light brood, all dead	:	:1.5 sq. ft. revealed very light living brood in all stages
181	Light	Heavy	:1.5 sq. ft. revealed light brood, all killed in spite of green, wet bark	:	:Heavy surviving brood
182	Med.	Med.	:1.5 sq. ft. uncovered medium larval brood under very thick bark--1 new adult living under $\frac{1}{2}$ " bark	:	:2 sq. ft. revealed heavy, living brood on SE side, rest a very light brood
193	Light	Light	:1 sq. ft. showed light, dead larval brood	:	:1 sq. ft. showed light brood living of pupae and new adults
194	Light	Light	:1.5 sq. ft. revealed light, dead larval brood	:	:1 sq. ft. uncovered light, living larval, pupal, and new adult brood

Table IV (Cont.)

SPRAYED JULY 9, 1937 WITH FORMULA B

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side			Brood on untreated side		
	Dead	Living	Dead	Living		
	Per sq. ft.	Percent of total on side	Per sq. ft.	Percent of total on side		
(1)						
10	15.2	90.5	1.6	9.5	.4	2.6
					14.8	97.4

Notes from Extensive Examination

Tree:Amount of brood :			(1)	:
no.	Treated	Untreated		
	: side	: side	Treated side	Untreated side
83	Heavy	Heavy	: 1 sq. ft. showed 6 larvae, 10 pupae, and : 12 new adults, all dead	: 1 sq. ft. revealed a heavy living brood of : 7 larvae, 3 pupae and 15 new adults--no : recent mortality
108	Med.	Light	: 1 sq. ft. revealed 6 new adults and 3 pupae : dead in deep creases and 1 living new adult : under about .35 bark thickness	: 1 sq. ft. showed 1 larva, and 2 new adults : only light brood had hatched and mortality : in early stages
117	Light	Light	: 1.5 sq. ft. showed no brood--poor tree for : treatment	: .75 sq. ft. revealed no living brood--mor- : tality occurred in small larval stage
120	Light	Light	: .75 sq. ft. reveals no surviving brood	: Light brood had reached new adult stage, then : died probably as result of extremely dry bark
135	Med.	Light	: 1 sq. ft. revealed 2 living larvae in a : moist spot under nearly .5 inch bark	: Scattered light brood all killed in new adult : stage
144	Heavy	Heavy	: 2 sq. ft. showed 6 larvae, 1 pupa, and 5 : new adults dead and 1 larva living under : 1 inch bark	: 1.5 sq. ft. revealed 15 living new adults : and no recent mortality
154	Light	Light	: 1.5 sq. ft. revealed perfect control	: .75 sq. ft. revealed light brood 0-3 larvae

Table IV (Cont.)

Notes from Extensive Examination					
Tree:	Amount of brood :		(1)		
no.	Treated:	Untreated:			
: side	: side		Treated side	:	Untreated side
:	:	:	:	:	
155	: Heavy	: Heavy	: 1.5 sq. ft. revealed dead brood of 16 new adults, 2 pupae, and 11 larvae	: 6 larvae, 1 pupa, 30 new adults on untreated side, living. No recent mortality	
	:	:	: 2 sq. ft. showed 8 larvae and 1 pupa dead	: 1.5 sq. ft. revealed no living brood, only parasites	
191	: Light	: Light			
	:	:	: 1 sq. ft. showed complete mortality	: 1 sq. ft. showed medium living brood with very little mortality	
199	: Med.	: Med.			

(1) North side 83-135; south side 144-199.

Formula C

This formula consisted of the following materials:

Light stove oil	---	4 parts
Orthene	---	1 part

This mixture also gave excellent control. The trees treated on June 23 showed only 1.4 percent survival on the treated side from the intensive examination data. The extensive examination data indicated an even higher percentage of control, and the average of the two shows about one percent survival.

Results from the July 9 treatment were not as good, but notes from the extensive examination indicate a higher average of trees with thick bark, wet bark, and green areas than in the other series so far discussed. The data from the extensive examination show only about 6 percent survival, and an average of both intensive and extensive shows less than 10 percent. If only a normal number of resistant areas on the treated trees were present in this group, it is believed the survival would be found to be less than 5 percent and place the group practically on a par in effectiveness with those treated with Formulas A and B. The data secured are shown in the two parts of table V.

Table V

MOUNTAIN-PINE-BIRTL-E-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
SPRAYED JUNE 23, 1937 WITH FORMULA C

Number of trees sprayed	Data from Intensive Examination of Base of Treated and Untreated Sides											
	Brood on treated side						Brood on untreated side					
	Dead	Percent of sq. ft.	Per total on side	Living	Percent of sq. ft.	Per total on side	Dead	Percent of sq. ft.	Per total on side	Living	Percent of sq. ft.	Per total on side
18	62	95.6		.9	1.4		2.9	10.4		24.9	89.6	

Notes from Extensive Examination

Tree:	Amount of brood:	Treated side	Untreated side
no. :Treated:Untreated:		(1)	
:side :side :			
:	:	:	:
78 : Light : Light	:1.5 sq. ft. showed only 1 larva living in a deep crease under thick bark--survival in sample unaccountable	:1 sq. ft. showed 2 larvae and 3 new adults	
:			
86 : Light : Light	:2.5 sq. ft. revealed very light dead brood except 3 under thick bark	:light brood living in all stages of development, 50% killed by Coeloides	
98 : Light : Light	:1 sq. ft. revealed complete control	:2 sq. ft. revealed 5 living new adults	
:	:1.5 sq. ft. --brood of dead larvae in base	:1 sq. ft. uncovered a light brood of living new adults in base of tree	
102 : Med. : Light	:		
:	:1 sq. ft. revealed 1 pupa, 2 new adults under thick-barked green spot	:1 sq. ft. yielded 3 larvae, 4 pupae, and 2 new adults	
104 : Heavy : Light	:2 sq. ft. showed no survivors even of larvae	:1 sq. ft. showed 1 larva, 1 pupa, 7 new adults	
112 : Med. : Med.	:from eggs laid in 1937 by overwintering parent adults	:living--considerable recent mortality with no indication of reason	
:			
119 : Heavy : Heavy	:2 sq. ft. revealed 3 larvae living under bark as much as 3/4 inch thick--much brood developed to new adults before controlled	:.75 sq. ft. revealed 16 new adults--bark over 1/2 inch thick in places	

Table V (Cont.)

Notes from Extensive Examination					
Tree:	Amount of brood :		(1)		
no.	Treated:	Untreated:			
:	:side	:side	Treated side	:	Untreated side
128	Heavy	Heavy	:1.5 sq. ft. revealed heavy brood killed even: :under bark 3/8 inch thick	:1.5 sq. ft. uncovered heavy brood, all stages,	
139	Heavy	Med.	:1 sq. ft. showed 2 larvae, 1 pupa, 2 new :adults living under wet portions of bark	:1 sq. ft. uncovered 1 pupa, 15 new adults :living--no recent mortality	
140	Light	Light	:2 sq. ft. showed 100% control light larval :brood	:.75 sq. ft. revealed very light brood of :living larvae, pupae and new adults	
156	Heavy	Heavy	:1.5 sq. ft. revealed 1 larva living for :which no reason can be given	:1 sq. ft. showed 16 new adults living--heavy :parasitism	
157	Light	Light	:1 sq. ft. uncovered light brood of larvae, :pupae, and new adults all dead, except 1 :pupa under thick piece of bark	:1.5 sq. ft. showed light brood of living :new adults	
184	Med.	Med.	:1 sq. ft. showed no survivors of the medium :brood	:.5 sq. ft. showed medium brood alive--no :recent mortality	
200	Light	Light	:.5 sq. ft. revealed no survivors	:.75 sq. ft. uncovered 12 larvae and 8 pupae :alive--larvae from eggs laid this spring by :overwintering parent adults	
204	Med.	Light	:1 sq. ft. uncovered 15 dead larvae	:1.5 sq. ft. revealed no brood	
150	Heavy	Heavy	:2 sq. ft. showed 100% mortality of heavy :brood of all developmental stages	:1.5 sq. ft. showed heavy survival, chiefly :new adults	
183	Med.	Med.	:2 sq. ft. revealed no survivors	:.5 sq. ft. showed medium brood in larvae, :pupae, and new adults	
195	Med.	Heavy	:1 sq. ft. showed no survivors	:1 sq. ft. revealed 17 new adults alive-- :heavy woodpecker work and thick bark	

(1) North side on trees 78-204; south side on 150, 183, 195.

Table V (Cont.)

SPRAYED JULY 9, 1937 WITH FORMULA C

Data from Intensive Examination of Base of Treated and Untreated Sides										
Number of trees sprayed	Brood on treated side					Brood on untreated side				
	Dead	Living	Dead	Living		Dead	Living	Dead	Living	
	Per sq. ft.	Percent of total on side	Per sq. foot	Percent of total on side		Per sq. ft.	Percent of total on side	Per sq. ft.	Percent of total on side	
10	6.8	85.0	1.2	15	:	2.4	15.4	13.2	84.6	:

Notes from Extensive Examination

Tree:	Amount of brood :	(1)			
no.	Treated:Untreated:	side	side	Treated side	Untreated side
246	Light : Light	:1.5 sq. ft. revealed light brood of 7 larvae	:3 sq. ft. showed light brood of new adults-- and 2 pupae dead and 1 larva living--no apparent reason for survival		: no recent mortality
247	Light : Med.	:.5 sq. ft. showed no survivors of light brood of new adults	:1 sq. ft. revealed medium brood of new adults living--no recent mortality		
253	Light : Light	:2.5 sq. ft. uncovered 2 larvae, 1 pupa, and 2 new adults, all dead--poor brood free	:3 sq. ft. revealed no brood--secondaries took over the side		
254	Light : Light	:1.5 sq. ft. showed light brood of 3 larvae and 4 pupae all dead	:2 sq. ft. showed no brood--bark tight and dry		
255	Heavy : Heavy	:2 sq. ft. revealed 3 living larvae under wet portion--heavy control even in wet portion	:2 sq. ft. revealed 6 larvae, 4 pupae, and 31 new adults all living--no recent mortality		
248	Med. : Light	:2 sq. ft. uncovered 6 larvae, 4 pupae, and 7 new adults all dead	:3 sq. ft. showed light brood of 6 new adults 2 pupae, and 4 larvae living		
249	Heavy : Light	:3 sq. ft. revealed 19 new adults and 9 pupae	:.5 sq. ft. revealed 5 new adults living-- all dead		: no recent mortality

Table V (Cont.)

Notes from Extensive Examination					
Tree:	Amount of brood :		(1)		
no.	Treated	Untreated			
side	: side		Treated side		Untreated side
250	: Light	: Light	: 1.5 sq. ft. showed light brood, all dead	: .5 sq. ft. uncovered light brood of larvae, : pupae, and new adults living	
251	: Med.	: Med.	: 1.5 sq. ft. revealed 2 living new adults of : medium brood controlled--no apparent reason : for survival	: .75 sq. ft. a medium brood of living new : adults showed no recent mortality	
252	: Med.	: Light	: 1.5 sq. ft. uncovered 1 living new adult of : a medium brood	: 2 sq. ft. uncovered light living brood of : larvae, pupae, and new adults	

(1) North side for 246-7 and 253-5; south side 248-252.

Formula D

This formula consisted of the following materials:

Sodium thiocyanate	---	one pound
Water	---	one gallon

The results from spraying with this mixture indicate it is ineffective as a control means. Data from the treated and untreated sides show there is a greater percentage of survival on the treated than on the untreated sides.

The data are shown in table VI.

Table VI

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL LIQUID
SPRAYED JUNE 25, 1937 WITH FORMULA D

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side			Brood on untreated side								
	Dead	: Percent of sq. ft.	Per total on side	Living	: Percent of sq. ft.	Per total on side						
	Dead	: Percent of sq. ft.	Per total on side	Living	: Percent of sq. ft.	Per total on side						
12	2.6	: 17.3	:	12.3	: 82.7	:	7	:	23.6	: 22.7	:	76.4

Notes from Extensive Examination

Tree:	Amount of brood :	Treated side	Untreated side
no.	Treated:Untreated: :side :side :		
79	- : -	:Material seems to have had corrosive effect :on bark--no apparent control	
87	- : -	:No recent mortality--even secondaries alive	
88	- : -	:Discolored bark but no evidence of control	
		:Brood alive from eggs laid by overwintering	
103	- : -	:parent adult	
115	- : -	:2 sq. ft. showed no control	:2 sq. ft. showed no living brood
		:2 sq. ft. showed 3 larvae dead and 4 pupae	:2 sq. ft. showed no brood
116	- : -	:alive	
132	Heavy : Heavy	:1 sq. ft. revealed heavy brood living pupae :1.5 sq. ft. revealed heavy brood pupae and :and new adults--recent mortality of 2 larvae: new adults	
141	- : -	:1 sq. ft. uncovered 1 larva, and 1 new adult:1 sq. ft. showed 1 new adult living :treatment ineffective	
189	- : -	:1 sq. ft. showed 1 larva, 2 pupae, and 3 new: :adults all living--no recent mortality--	
		:treatment a failure	

Table VI (Cont.)

Notes from Extensive Examination

Tree:	Amount of brood :		
no.	Treated	Untreated	
: side	: side		
		Treated side	Untreated side
196	-	-	
	:	: 1 sq. ft. uncovered 1 larva, 7 new adults--	: .5 sq. ft. uncovered 2 larvae and 18 new
	:	: slight recent mortality--treatment ineffec-	: adults
	:	: tive	
	:	: .25 sq. ft. revealed 11 new adults--no	: .5 sq. ft. revealed 1 pupa and 5 new adults
197	-	-	
	:	: apparent recent mortality	
	:	: Living brood of 15 new adults and 3 dead	: 2 sq. ft. showed 3 pupae and 10 new adults
211	-	-	
	:	: larvae	: living and 1 dead larva

Formula E

This formula consisted of the following materials:

Mineral spirits	---	3 parts
Orthene	---	1 part

Control secured from this oil was good, but not as high as with Formulas A, B, and C. It is felt that this oil has shown too little effectiveness to warrant further consideration.

The data secured are shown in table VII.

Table VII

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
SPRAYED JUNE 25, 1937 WITH FORMULA E

Data from Intensive Examination of base of Treated and Untreated Sides										
Number of trees sprayed	Brood on treated side					Brood on untreated side				
	Dead	Percent of total on side	Per sq. ft.	Living	Percent of total on side	Per sq. ft.	Dead	Percent of total on side	Per sq. ft.	Living
	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :	: : : : :
10	20	: 75.5	: : : : :	6.4	: 24.2	: : : : :	1.6	: 7.8	: 15.8	: 92.2

Notes from Extensive Examination

Tree: Amount of brood :							
no.	Treated:Untreated:	: : : : :		: : : : :		: : : : :	
	side	side		Treated side		Untreated side	
203	Med. : Heavy	: .5 sq. ft. yielded 4 larvae living--control	: .25 sq. ft. showed 30 new adults living and				
		: had occurred in mature larval and pupal stages	: 2 larvae and 1 pupa dead				
224	Light : Light	: 2 sq. ft. showed only 5 dead larvae--no living brood	: 1.5 sq. ft. revealed 5 new adults living and				
			: 2 dead larvae				
225	Med. : Heavy	: 1.5 sq. ft. revealed 49 larvae living under .5 sq. ft. yielded 9 larvae, 5 pupae, and 75 : 1 inch thick green bark		: new adults living			
226	Med. : Heavy	: 3 sq. ft. yielded 10 larvae dead and 5 larvae living--the latter being protected by thick bark	: 2 sq. ft. showed 6 larvae, 3 pupae, and 20 new adults living--no recent mortality				
227	Med. : Med.	: 2 sq. ft. showed 1 new adult living	: 1.5 sq. ft. revealed 18 larvae, 2 pupae, and 8 new adults--no recent mortality except by parasites				
228	Light : Light	: 1.5 sq. ft. revealed no living brood	: Light brood				
		: 1 sq. ft. yielded 1 larva and 1 new adult	: .75 sq. ft. yielded heavy brood which showed little recent mortality				
229	Light : Heavy						

Table VII (Cont.)

Notes from Extensive Examination					
Tree: Amount of brood :					
no. :Treated:Untreated:					
:side	:side	:	Treated side	:	Untreated side
:	:	:		:	
230	: Light	: Light	: 1 sq. ft. showed 1 larva, 2 pupae living and: 3 sq. ft. showed 3 new adults living--no : 3 larvae dead		: recent mortality
231	: Light	: Light	: 3 sq. ft. revealed 6 larvae dead and 2 pupae: 1 sq. ft. revealed 1 larva, 4 pupae and 5 : living--no apparent reason for survival	: new adults living	
232	: Light	: Light	: 1.5 sq. ft. yielded 3 larvae and 1 new adult: 1 sq. ft. uncovered 4 new adults alive-- : living in very moist place		: some recent mortality

Formula F

This formula consisted only of light stove oil which was tested to determine if it had any lethal effect on bark beetle broods. The data from both intensive and extensive examinations indicate the oil has considerable lethal effect even without the addition of other materials, but does not give sufficient control to warrant its use without the addition of a more lethal agent.

Table VIII presents the data secured.

Table VIII

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
SPRAYED JUNE 25, 1937 WITH FORMULA F

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side				Brood on untreated side			
	Dead	Percent of sq. ft.	Per total on side	Living	Dead	Percent of sq. ft.	Per total on side	Living
	Per sq. ft.	:Percent of total on side:	Per sq. ft.	:Percent of total on side:	Per sq. ft.	:Percent of total on side:	Per sq. ft.	:Percent of total on side
11	12.73	: 60.4	:	8.36	:	39.6	:	-
								24.36 : 100

Notes from Extensive Examination

Tree:	Amount of brood :	Notes from Extensive Examination			
no.	Treated:Untreated:	(1)			
	:side :side	Treated side	Untreated side		
81	Light : Med.	:2 sq. ft. showed a light brood with about 25% survival--treatment apparently ineffective	:1.5 sq. ft. revealed medium brood in all stages of development with considerable recent mortality in larval stage		
90	Light : Light	:4 sq. ft. revealed no brood	:3 sq. ft. showed 5 pupae living--most of side green		
105	Light : Light	:2 sq. ft. uncovered 6 larvae dead	:1.5 sq. ft. uncovered 7 new adults alive		
106	Light : Med.	:2 sq. ft. yielded light brood of larvae, pupae, and new adults, half of which were living--treatment apparently ineffective	:2 sq. ft. revealed medium brood of living new adults and pupae--no recent mortality		
122	Med. : Med.	:2 sq. ft. showed 15 new adults and 1 pupa living and 3 larvae dead	:1 sq. ft. yielded 12 new adults living--no recent mortality		
136	Light : Med.	:1.5 sq. ft. revealed 1 larva and 1 new adult:1 sq. ft. showed 1 larva, 3 pupae, and 14 living--no apparent reason for larva's survival--new adult near edge of treated area	:new adults living--no recent mortality		
142	Heavy : Heavy	:2 sq. ft. uncovered 4 larvae, 3 pupae, and 2 new adults living and 7 larvae dead--treatment unsuccessful	:3 sq. ft. showed heavy living brood in all developmental stages		

Table VIII (Cont.)

Notes from Extensive Examination					
Tree:	Amount of brood :		(1)		
no.	Treated:	Untreated:			
	: side	: side	Treated side	:	Untreated side
180	: Light	: Med.	: 1 sq. ft. showed 6 larvae, 2 pupae, and 5 new adults under thick, moist bark--treatment only partly effective	: .5 sq. ft. revealed 11 larvae and 5 new adults living	
187	: Light	: Light	: .5 sq. ft. yielded 8 larvae living from eggs: laid in 1937--no recent mortality--treatment: ineffective	: .5 sq. ft. yielded 1 larva and 2 pupa living	
212	: Med.	: Heavy	: 2 sq. ft. uncovered 2 larvae and one new adult living and 5 larvae, 3 pupae, and 8 new adults dead--treatment partly effective	: Heavy living brood in all stages of development	
215	: Med.	: Med.	: 1 sq. ft. revealed 1 larva and 1 new adult living, indicating good but not perfect control	: 1 sq. ft. showed 4 larvae, 2 pupae, and 9 new adults living--little recent mortality	

(1) North side on all but 212 and 215, which were on south side.

Formula G

The materials used in this formula were the following:

Kerosene	---	3 parts
Orthene	---	1 part

The objective sought with kerosene as the carrier of the lethal agent was to find a material more readily penetrating bark than fuel oil. Intensive examination of the few trees sprayed showed perfect control, but the extensive examination revealed a few living insects and reduced control to about 97 percent. Although giving control almost equal to that secured with fuel oil as the penetrant, kerosene is so much more expensive that the former is to be preferred.

Data for the experiment are shown in table IX.

Table IX

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
JUNE 25, 1937 WITH FORMULA C

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on treated side				Brood on untreated side			
	Dead	Percent of sq. ft. total on side	Per sq. ft.	Percent of total on side	Dead	Percent of sq. ft. total on side	Per sq. ft.	Percent of total on side
	:	:	:	:	:	:	:	:
5	35.2	100	-	-	-	-	14.4	100

Notes from Extensive Examination

Tree:	Amount of brood :	Treated side	Untreated side
no.	Treated:Untreated:		
:	:	:	:
213	: Light : Light	: 1.5 sq. ft. revealed 1 larva and 1 pupa : living--moist bark may account for survival	: 1.5 sq. ft. showed 3 larvae and 5 new adults : living--little recent mortality
216	: Heavy : Light	: 2 sq. ft. showed 46 larvae dead--treatment : very good	: 1.5 sq. ft. revealed 4 larvae, 1 pupa, and : 6 new adults all living
217	: Heavy : Light	: 2 sq. ft. uncovered 43 larvae, dead	: 1.5 sq. ft. uncovered 10 new adults living : --no recent mortality
218	: Med. : Heavy	: 1 sq. ft. showed 3 larvae, 1 pupa, and 4 new : adults alive, indicating good but not per-	: 1 sq. ft. yielded 1 larva, 3 pupae and 15 : new adults
219	: Heavy : Light	: 1.5 sq. ft. revealed 18 larvae, dead	: 1 sq. ft. showed 2 larvae and 5 new adults : --no recent mortality

Formula H

The materials in the formula were as follows:

Stoddard solvent	---	3 parts
Orthene	---	1 part

Again it was with the idea of finding a more efficient carrier of the lethal material that prompted the use of the Stoddard solvent. Indications from the extensive and intensive examinations were that from 6 to 10 percent of the brood had survived from this treatment. This degree of control was somewhat less than with some of the other formulae, and in addition is considerably more expensive. For the above reasons it is not as desirable as the mixtures in which fuel oil is the penetrant.

Table X shows the data.

Table X

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH LETHAL OIL
JUNE 25, 1937 WITH FORMULA H

Data from Intensive Examination of Base of Treated and Untreated Sides

Number of trees sprayed	Brood on Treated Side				Brood on Untreated Side			
	Dead	Living	Dead	Living				
	Per sq. ft.	:Percent of total on side:	Per sq. ft.	:Percent of total on side:				
12	18.3	: 91.2	1.8	: 8.8	2.6	: 9.9	23.3	: 90.1

Notes from Extensive Examination

Tree:	Amount of brood :		
no.	Treated:Untreated:	(1)	
	:side :side :	Treated side	Untreated side
:	:	:	:
99	: Light : Heavy	:1.5 sq. ft. yielded 3 larvae and 2 pupae : living, bark over survivors up to .3 inch : and moist	:1 pupa and 30 new adults indicates heavy : brood--little recent mortality
109	: Heavy : Med.	:1 sq. ft. showed 34 larvae, 1 pupa, dead	:.5 sq. ft. yielded 9 larvae and 13 new adults :--little recent mortality
113	: Light : Light	:2 sq. ft. uncovered 1 larva under wet spot : in bark	:1 sq. ft. showed 1 pupa, 2 new adults
158	: Light : Light	:2.5 sq. ft. revealed 1 pupa under very thick: : bark in furrow of tree	:2 sq. ft. uncovered light brood in all stages :of development
162	: Light : Light	:.5 sq. ft. showed no surviving brood	:.5 sq. ft. yielded 3 new adults living--no :recent mortality
178	: Light : Light	:2 sq. ft. showed 11 dead larvae, none living	:1 sq. ft. showed 2 new adults living--no :recent mortality
185	: Light : Light	:1.5 sq. ft. revealed 15 dead larvae	:1 sq. ft. uncovered 7 new adults living-- :no recent mortality

Table X (Cont.)

Notes from Extensive Examination

Tree: Amount of brood:				
no.	Treated:	Untreated:	(1)	
	: side	: side	Treated side	
207	: Light	: Med.	: 1.5 sq. ft. uncovered 9 larvae living from : green area	: .5 sq. ft. yielded 13 larvae, 5 pupae, and : 4 new adults living
208	: Med.	: Heavy	: 2 sq. ft. showed 3 larvae, 2 pupae, and 2 : new adults surviving--treatment none too : good	: .5 sq. ft. uncovered 25 larvae and 2 new : adults--larvae from this year's eggs
201	: Light	: Light	: 3.5 sq. ft. showed 21 larvae, 3 pupae and : 1 new adult dead	: 2 sq. ft. revealed 15 larvae and 3 pupae : living--no recent mortality
209	: Med.	: Heavy	: 1.5 sq. ft. revealed 6 pupae and 3 new : adults, dead	: 1 sq. ft. revealed 20 new adults and 3 pupae : living--no recent mortality

(1) North side except for 201 and 209, which are on south side.

Table X (Cont.)

SPRAYED JULY 9, 1937 WITH FORMULA N

Data from Intensive Examination of Base of Treated and Untreated Sides															
Number of trees sprayed	Brood on treated side					Brood on untreated side									
	Dead	Per sq. ft.	Percent of total on side	Living	Per sq. ft.	Percent of total on side	Dead	Per sq. ft.	Percent of total on side	Living					
	;	:	:	;	:	:	;	:	:	;					
10	16.4	:	89.1	:	2	:	10.9	:	2.8	:	33.3	:	5.6	:	66.7

Notes from Extensive Examination

Tree:	Amount of brood :									
no.	Treated:Untreated:									
:side	:side	:		Treated side		:			Untreated side	
:	:	:				:			:	
125	Light	Light	:1.5 sq. ft. showed 1 larva, 2 pupae, and :4 new adults, dead			:3 sq. ft. revealed 3 new adults living				
127	Light	Light	:1 sq. ft. revealed no survivors of treatment: :1.5 sq. ft. yielded 1 new adult, 5 larvae; :1 sq. ft. yielded light brood of new adults							
147	Heavy	Light	:latter in deep crease							
148	Light	Light	:1.5 sq. ft. showed 4 new adults, dead			:1 sq. ft. yielded 3 new adults, living				
183	Light	Light	:1.5 sq. ft. revealed 3 new adults and 1 larva, dead			:1.5 sq. ft. showed no brood				
190	Med.	Heavy	:6 new adults, dead							
214	Light	Light	:1.5 sq. ft. showed 5 larvae, 2 pupae, and :2 new adults, dead			:1.5 sq. ft. uncovered 22 larvae, dead				
243	Light	Light	:1 sq. ft. showed 1 new adult, living			:1 sq. ft. revealed light, living brood in :new adult stage				

Table X (Cont.)

Notes from Extensive Examination					
Tree:	Amount of brood :		(1)	:	
no.	Treated	Untreated:			
	: side	: side	Treated side	:	Untreated side
244	: Light	: Light	: 1.5 sq. ft. revealed 100 percent mortality : of light brood	:	: 1 sq. ft. uncovered light, living brood in : new adult stage
245	: Light	: Med.	: 2 sq. ft. uncovered only 6 dead larvae	:	: 2 sq. ft. yielded 15 new adults living--no : recent mortality

(1) North side 125-188, south side 190-245.

Formula I

In this test orthene was used undiluted.

The objective of the experiment was to determine any variation that might exist in the effectiveness of orthene pure and orthene diluted with oils.

Both the intensive and extensive data show light survival on the treated side, indicating that pure orthene is no more effective than when in mixture with fuel oils.

The data are given in table XI.

Table XI

MOUNTAIN-PINE-BEETLE-INFESTED LODGEPOLE PINE SPRAYED WITH INTHAL OIL
JUNE 25, 1937 WITH FORMULA I

Data from Intensive Examination of Base of Treated and Untreated Sides										
Number of trees sprayed	Brood on treated side					Brood on untreated side				
	Dead	Percent of Per sq. ft.	Living	Percent of Per sq. ft.	Dead	Percent of Per sq. ft.	Living	Percent of Per sq. ft.	Dead	Percent of Per sq. ft.
	total on side	total on side	total on side	total on side	total on side	total on side	total on side	total on side	total on side	total on side
	:	:	:	:	:	:	:	:	:	:
5	32.5	97.6	.8	2.4	1.6	10.5	13.6	89.5		

Notes from Extensive Examination

Tree: Amount of brood:				Treated side		Untreated side	
no.	Treated:	Untreated:	:side	:side	:	:	
210	Med.	Med.	:1	sq. ft. showed no surviving D.m. brood		:.75 sq. ft. showed 2 larvae and 15 new adults, living--very little recent mortality	
	:	:					
220	Light	Light	:2	sq. ft. uncovered 12 larvae, dead		:1 sq. ft. revealed only 4 new adults, living	
	:	:					
221	Light	Med.	:2	sq. ft. yielded 25 larvae dead		:2.5 sq. ft. uncovered 6 larvae, 7 pupae, and 9 new adults living	
	:	:					
222	Light	Light	:1	sq. ft. showed 100% control of light brood	:.5 sq. ft. showed 3 new adults alive and many Coeloides sp. parasites		
223	Light	Light	:1.5	sq. ft. revealed 13 larvae dead & 1 living	:1 sq. ft. revealed no brood		

SUMMARY

During 1937 various mixtures of lethal oils and one aqueous solution were tested in the search for a spray which when applied to the bark of mountain-pine-beetle-infested lodgepole pine would kill the infesting brood.

A number of the formulae tested in 1937 gave excellent results, including A, B, C, E, G, H, and I. All but three of these mixtures, however, were too costly to be practical for general control.

On the basis of the 1937 and previous experiments, Formula A has given the most consistently favorable results. However, with both naphthalene and orthene in its composition, it is more expensive than those in which only orthene or naphthalene are mixed with the fuel oil.

The 1936 and 1937 experiments with fuel oil and orthene gave excellent results, but the orthene is more expensive than naphthalene, and being a liquid is not as readily adapted to field use as the crystalline naphthalene. Naphthalene, however, does not dissolve readily in fuel oil until the latter is heated to about 100° F., and the time and equipment needed for this heating probably places the formula comprising fuel oil and naphthalene practically on a par as to cost with the one containing fuel oil and orthene.

The desired 100 percent control has not been consistently obtained with any of the formulae. Green or partly green bark areas or areas

of bark having a high moisture content are usually those under which survival has been noted. It is believed that the more or less moisture-saturated condition of the bark prevents the absorption and penetration of the oils.

Although complete control was not realized with any of the formulae tested, such a high percentage of kill was obtained with mixtures of fuel oil and naphthalene or orthene, or both, that their use for bark beetle control in lodgepole pine seems quite feasible and warrants further tests with formulae A, B. and C.

Respectfully submitted,

A. L. Gibson
Assistant Entomologist